Image Deblocking With 2-D Hermite Transform

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Abstract

New method to eliminate block artifact in high compressed images is presented. Here the emphasis is placed on Hermite transform and we also accentuate on pixel near the block boundaries, and, because it is a polynomial transform with a gaussian window that is in a good agreement with human visual processing procedure.

Keywords: *Image de-blocking, Hermite transform, image filtering.*

1. INTRODUCTION

Advance over the two past decays in digital technology has brought many applications of digital imaging. By the way data storage and data transmission applications are very important. With the increasing need to image transmission and storage, the demand for higher compression is also increasing. Today transform block coding on basis of linear transforms (LT) (forward LT – FLT and inverse LT – ILT) is extensively used in low bit rate compression. As the most important example, joint ISO/CCITT committee known as JPEG (Joint Photographic Expert Group) proposed more than decay ago standard for images [1], both grayscale and color, and also for the past few years MPEG-4 for video sequences.

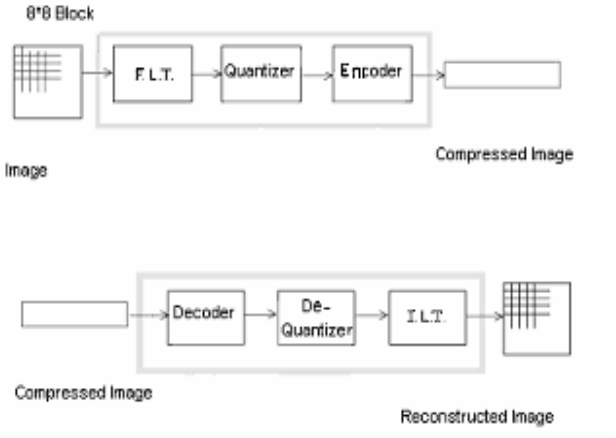


Figure1: Block Diagram Coder And Decoder In Block Coding

Different image compression methods have different artifacts, and image block coded at low bit rate loses some details and sharpness. In block coding image is usually divided into non-overlapping square blocks and LT is applied to each block. If we wish to achieve high compression rate (low bit rate), using block coding, we find a visually noticeable change in intensity values along block boundaries that is called block artifact. Block artifact is mainly caused by considerable quantization errors of LT coefficients. The procedure of eliminating the block artifacts is called de-blocking.

Block-DCT based coder is still one of the main compression tools used for still images and video sequences. Input image samples of this encoder are grouped into 8*8 blocks, and discrete cosine transform is used as LT. Wavelet transform as LT is used in Jpeg-2000. Wavelet-based image coding shows some advantages over the traditional DCT block-based method in terms of visibility and block artifacts in compressed images. However, the coded images still have artifacts both in continuous region and near sharp edges. In both cases, quantization error in high-frequency sub-bands generally results in ringing effects, as well as blurring effect near sharp edges, and those in both low-frequency and high- frequency sub-bands cause blotchiness in smooth region [2].

Among the approaches to improve the subjective quality of images, postprocessing appear to be the most practical solution. It does not require changes to existing standard, and with the rapid increase of available computing power more complex methods can be implemented. In various postprocessing techniques, excessive blurring is often introduced and in many cases they produce poor deblocking results at monotone area of the image [3]. Some methods try to recover the edges using an edge-model dependent or edge-model independent approaches for specific coding processes, and some works focus on cyclic time invariance introduced by block-based and sub-band transform coder [4]

Previous post-processing techniques with image restoration share some characteristics:

a. for real-time application, like video, these algorithms may be unacceptable because often require intensive computations or additional hardware .

b. There are not explicit or deterministic characterizations of the degradation process [2].

c. In compressed image deblocking based-on DCT, ringing effect is seldom taken into consideration, and in images compressed using wavelet approach the main consideration is on ringing effect [5].

Compressed image artifact suppression is still of great concern in information technology. Here we can also mention that image visual quality can be improved by accentuating some image features without considering image fidelity criteria like PSNR (Peak –Signal to –Noise –Ratio) metrics.

Our work, based on Hermite transform use for image postprocessing, is mainly concerned image deblocking. Nevertheless ringing artifact suppression is also taken into consideration.

2. POSTPROCESSING

Our method of filtration is based on Hermite transformation. The key idea is that the proposed method roughly simulate model of information filtering in human visual system.. For previous use of Hermite transform technique in different image processing tasks see [6-8].

2.1.Hermite transform

Spatial function in the Sturm-Liouville boundary value problem, which arises, as an example, in the treatment of the harmonic oscillator in quantum mechanics, is called Hermite function. Set of orthogonal Hermite functions is complete in $L_2(-\infty,\infty)$.

One of the most important properties of these functions is the fact that they are the eigenfunctions of Fourier transform:

$$F(\psi_n)=i^n\psi_n,$$

where F denotes Fourier transformation.

Thus expansion of a signal into a Hermite functions series gives us at same time the information on Fourier transform of the signal.

Onedimensional and 2D Hermite functions can be found using recursive or Rodrigues formulae. Formally 2-D Hermite functions can be defined as:

$$\psi_{nm}(x,y)=\frac{(-1)^{n+m}e^{x^2/2+y^2/2}}{\sqrt{2^{n+m}n!m!\pi}}\cdot\frac{d^n(e^{-x^2})}{dx^n}\cdot\frac{d^m(e^{-y^2})}{dy^m}$$

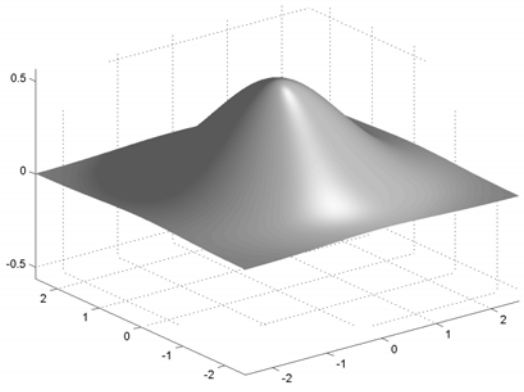


Figure 2a

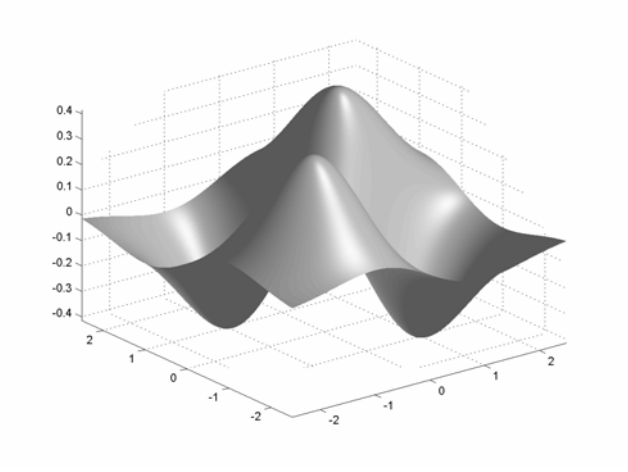


Figure 2b

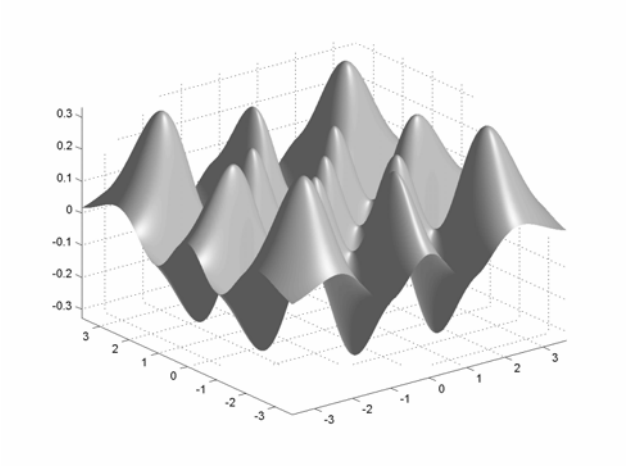


Figure 2c

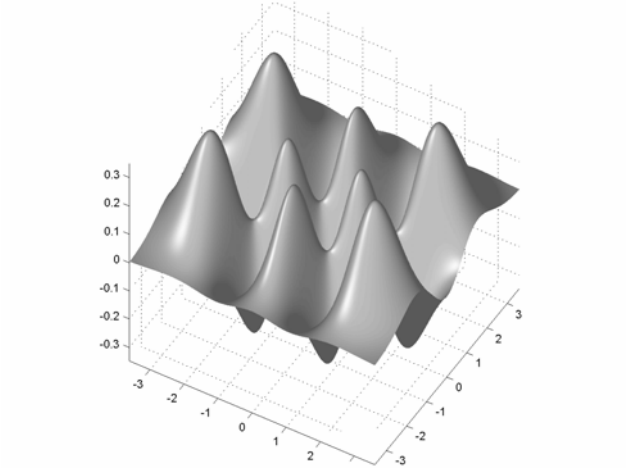


Figure 2d

Figure2: The graphs of the 2D Hermite functions a: $\psi_{0,0}(x,y)$, b: $\psi_{1,1}(x,y)$, c: $\psi_{4,4}(x,y)$, d: $\psi_{2,4}(x,y)$

2.2. Image Filtering

Before image transformation using Hermite expansion we apply a Hamming window and subtract baseline in every row and column to avoid boundary Gibbs effect. (Fig.3)

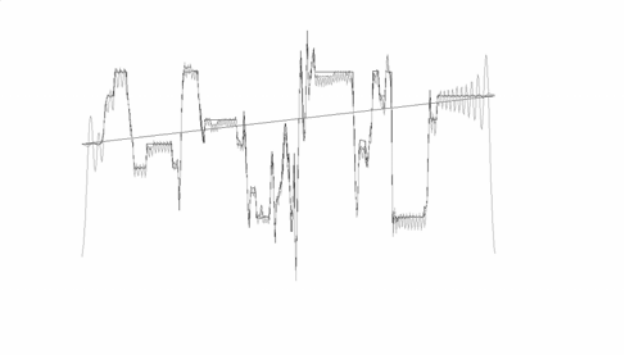


Figure 3: Image intensity Hermite approximations (dark line – with baseline subtraction, light gray- without baseline subtraction).

After that we should select the intervals $[-a_x, a_x], [-a_y, a_y]$ to set the scale of data information. They depend on number of the Hermite functions to be used for image filtering. The intervals are defined from the following criteria:

$$a_x = \max_x \left(\arg_x (\psi_n(x) = 0.01) \right),$$

$$a_y = \max_y \left(\arg_y (\psi_m(y) = 0.01) \right).$$

where n, m denotes the number of functions for x, y directions.

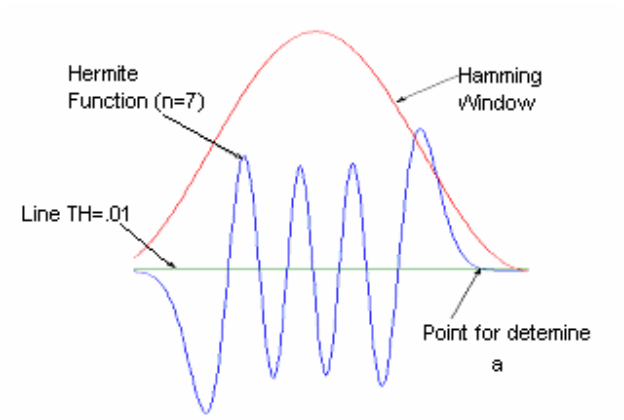


Figure 4: Hermite function (n=7) and its Threshold line (TH=0.01)

Then we filter image, basing on decomposition of the image function *f(x, y)* into Fourier series by Hermite functions:

$$f(x,y) = \sum_{i=0}^{n} \sum_{j=0}^{m} c_{ij} \psi_{ij}(x,y));$$

$$c_{ij} = \int_{-a_x}^{a_x} \int_{-a_y}^{a_y} f(x,y) \psi_{ij}(x,y) dxdy$$

2.3. Results

Different de-blocking algorithms performance was previously compared in [2],[4]. Lena image with different PSNR level compression was tested. We also applied our algorithm to Lena 512*512 images with PSNR values close to [2],[4] images.

Two variants of our algorithm were tested. First of them is the algorithm described above (Hermite1) and the same scheme was used for the second method (Hermite2) but here we processed information on image intensity for pixels near block boundaries. So only n*8, n*9 columns and m*8,m*9 lines of image (n,m=1-63) were used when we calculated coefficients of Hermite expansion.

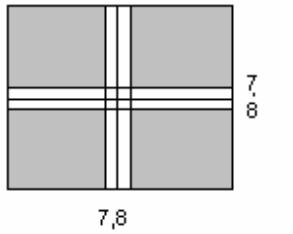


Figure 5: Information used in Hermite2 method (white area).

Our results on PSNR improvement by both variants along with the results given in [2],[4] are listed in the table below:

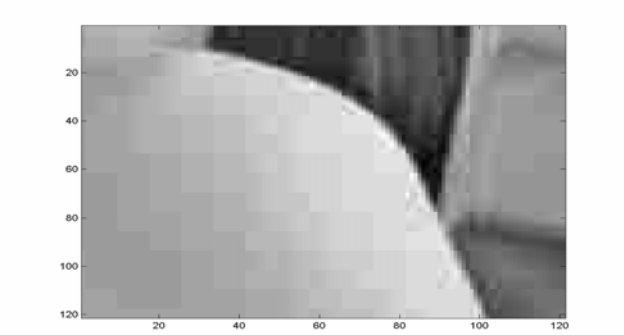
	PSNR=26.36	PSNR=29.70	PSNR=32.30
POCS[2]	1.14	.85	.45
Wavelet[2]	1.14	.79	.1
Adaptive[2]	1.06	.79	.45
Hermite1	0.55	0.43	0.24
Hermite2	0.65	0.53	0.37
Embeded[2].	1.17	1.0	.65
Model_based edge[4]	-	.25	.13

Table: PSNR improvement by different methods for compressed Lena images

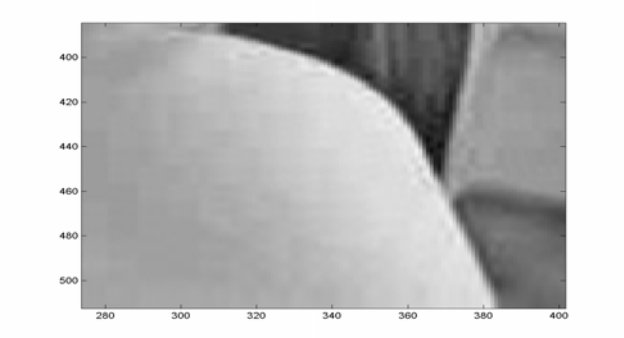
The results show that Hermite2 variant that uses information on block boundaries is not much better in terms of PSNR metrics than the general Hermite1 procedure. Nevertheless, the results given in the table show that the proposed Hermite1 method looks promising enough, because no initial information on block boundaries positions and blocks size were used in this case. It is also necessary to mention that PSNR values do not give us a reliable criterion to compare de-blocking effect, but visual

examination is necessary to make real conclusions. Obtained Hermite1 filtered images show very good visual characteristics.

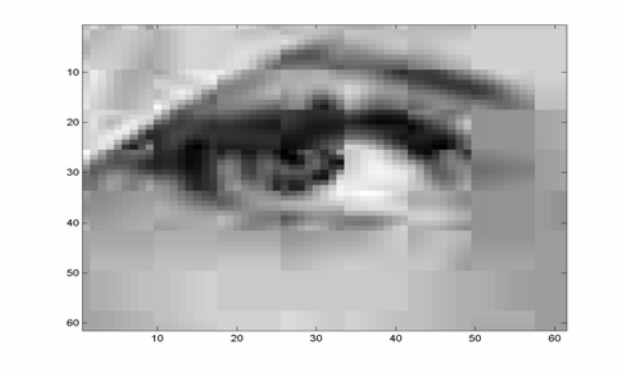
The results of Hermite1 method are shown in the pictures below:



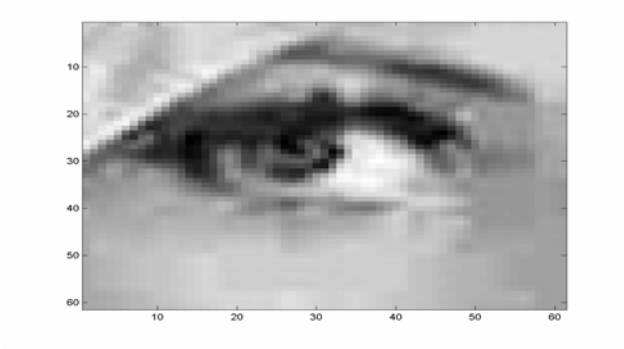
Compressed image



Hermite filtered compressed image



Compressed image



Hermite filtered compressed image

3. CONCLUSION

New filtering method for image recovery was proposed to decode block-transform compressed images. The main advantage of this approach is that the image is reconstructed without prior knowledge of compression method, and therefore it is useful for every encoder. The penalty for the improvement in image quality in complex method is an increase of time processing but our algorithm gives effective results in terms of visual quality.

4. REFERENCES

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